

- 2145 *Teucrium foliis ovatis acute incisoferratis glabris, floribus axillaribus geminis caule, erecto.*
Linn. Sp. plant. 790.
- 2146 *Tithymalus Linariæ folio, lunato flore.* Mor.
H. Reg. Blef.
2147. *Valeriana fylvestris major altera, fol. lucido.*
H. Reg. Par.
2148. *Veratrum racemo composito, corollis patentiffimis.* Linn. Sp. plant. 1479.
- 2149 *Veronica racemis lateralibus, foliis lineari lanceolatis pinnato dentatis.* Linn. Sp. plant.
17.
- 2150 *Volkameria ramis inermibus.* Linn. Zeyl. 231.

XVI. *A Course of Experiments to ascertain the Specific Buoyancy of Cork in different Waters: The respective Weights and Buoyancy of Salt Water and Fresh Water: And for determining the exact Weight of Human and other Bodies in Fluids.* By John Wilkinson, M. D. F. R. S. of London and Gottingen.

[*Experiments to determine the Specific Buoyancy of Cork in River Water.*]

Experiment I.

Read March 14, 1765. **S**IX cubes of good cork, every one measuring an inch square, as nearly as they could possibly be ascertained, with a graduated

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duated gage of cork fastened to a point of each, severally weighed as follows;

	Grains
N ^o 1	49
2	$47 \frac{1}{4}$
3	47
4	$46 \frac{1}{2}$
5	46
6	43

Sum of Weights 279 $\frac{1}{2}$ Grains.

the medium weight, being the exact weight of a cubic inch of cork is $46 \frac{6}{7}$.

Experiment II.

N^o 1, 2, 3, 4, formed a float named A, being 190 grains of cork, which was fastened to a medallion of lead, weighing two ounces, by a wire that weighed eight grains; these being put into a deep jar of Thames water, taken above the new bridge, the lead weighed exactly 44 grains; so that 190 grains of cork supported precisely 916 grains of lead in river water.

Experiment III.

The float was left in the same water, immersed by the medallion for the space of 48 hours, with a view of obtaining a precise knowledge of the quantity of water the cork might imbibe; how its buoyancy might be affected; and how much extension it might acquire from a certain continuance under the water.

It was somewhat surprising to find, that after this period of immersion the cork had not, as might have been expected, lost any force of buoyancy; but on the contrary, it had actually gained two grains, and was found to support 918 grains of lead: which must be attributed, it may be presumed, to an expansion of the air contained in the cork, acquired from its immersion in the fresh water.

To be further informed how cork would be affected by a continued immersion, the same float, after weighing, was again immersed in the same water, for the space of 48 hours longer. And now the water was found to have penetrated its recesses and cavities, in so much that its buoyancy had decreased 11 grains, and it then only supported 905 grains. This decrease may possibly be attributed to a greater imbibition in the cork, and a greater penetration given to the water, by its having been now 96 hours in a chamber, with a fire in it, by which it might be warmed. This float A being taken out of the water, wiped, and laid in a dry place for 24 hours, weighed 211 grains, having gained by absorption 21 grains of additional weight.

Experiment IV.

The float, in this state, having been 24 hours out of the fresh water, was now put into salt water brought from the North Foreland, in which it was found to support the weight of 954 grains, of a leaden medallion, having the power of buoying up 38 grains more in the sea water, than it did in the river water, with which it was nearly saturated at the time of its immersion in the sea water.

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After an immersion of 48 hours in the salt water, this float (A) lost 16 grains of its buoyant power; and having been 72 hours in the salt water, upon weighing of it again out of the water, being wiped, but full of water, it was found to weigh 241 grains, having gained 30 grains. After being nine hours out of the water, in a dry room, it weighed 213 grains, having lost 28 grains. This float (A) having been 76 hours in the salt water, in which it then sustained 949 grains of lead was removed, thus saturated with the sea water, into a vessel of fresh river water, and was found to sustain 923 grains only, being 26 grains less than it bore up in the salt water; and yet it must be observed, that this float had been saturated with fresh water before it was immersed in the salt water.

Experiments made to discover the Specific Buoyancy of Cork in Salt Water.

Experiment V.

Not content merely to know the buoyant power of cork in fresh water, it was next tried in sea water. Four cubes, being each an inch square on every side, made of the best found compact cork, with distinct gages made of cork, and adjoining, as in the preceding experiments, were prepared, each weighing as follows;

	Grains
N ^o 1	42
2	$42 \frac{1}{2}$
3	54
4	53
5	43

Amounting in all to $234 \frac{1}{2}$ Grains.

these

these being united, formed one float (marked B) that they might the nearer resemble the texture of the cork jacket. A vessel of sea water taken up near the North Foreland being then provided, the float was found to support in it a leaden medallion weighing 1048 grains. When it had continued in the sea water for 48 hours, it exactly supported 1024 grains, having, by being in the salt water, for that space of time, lost 24 grains of its buoyant power.

From this experiment we learn, that the salt water insinuates more into the substance of cork than fresh water doth, which may perhaps be attributed to its oiliness, * oil being, as is very well known, more subtil and penetrating, than water; it could not therefore be expected that the cork should therein retain its force so vigorously, for so long a time, as it doth in the fresh river water; and, on weighing, it was found to lose $\frac{1}{39}$ of its buoyancy in 48 hours.

But then we are further to observe from the above, that the sea water supports a greater weight, and gives more buoyancy to the cork float than fresh water, in the proportion of 353 to 359; for a float weighing 44 grains, supporting 353 grains of lead in fresh water, buoyed up 359 grains of lead in the sea water, being more by six grains. And it is to be noted, that the sea water taken up at the North Foreland is not so much impregnated with the marine principles, as that which is taken up at a greater distance from fresh water rivers, which decreases in its buoyancy in

* Vid. Macellinus. Pliny (Lib. xxxi. Cap. 7.) P. Bourges (Lett. Missionnaires, Octav. Edit.) and Dr. Hales.

proportion to its vicinity to or mixture with rivers ; for on evaporating it yielded only two drachms and one grain of falt to a pint, which is lefs by seven grains than is yielded by that taken up at the Ifle of Wight.

Experiment VI.

The float B being continued in immerfion in falt water for 72 hours, it had loft 26 grains more of its buoyant force, lofing in the firft 48 hours 24, and in the 24 fucceeding hours two grains only ; from which it appears, that, after the cork has been in the water for 48 hours, its abforption becomes lefs than before, in proportion as 12 is to 1.

This float having continued in the water for 78 hours, each piece of cork, being wiped very dry on its furface, but not squeezed, weighed as follows ;

N ^o 1 weighed	$55 \frac{1}{2}$	Grains having gained	12	Grains
2	47		$4 \frac{1}{2}$	
3	66		12	
4	$59 \frac{1}{2}$		$5 \frac{1}{2}$	
5	$51 \frac{1}{2}$		$8 \frac{1}{2}$	
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All 5 weigh.	$279 \frac{1}{2}$	gained	$42 \frac{1}{2}$	
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Being then defirous to know if any quantity of falt had infinuated into the pores of the cork, and if fo, how much ; the above float was hung up to dry in a warm airy room, where it was not far from the fire, for the fpace of 48 hours ; when it feemed to
be

be quite dry, and each piece being weighed, was found as follows;

	Gr.		Gr.
N ^o 1 weighed	45	the falt supposed to be contained was	3
2	46		3½
3	59		6
4	55		2
5	44		1
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All 5 weigh.	249	falt gained	15½
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But on their being hung near a fire for 72 hours, until perfectly dry, no falt appeared to be imbibed, for the above numbers weighed as follows; having lost by extraordinary dryness about $\frac{1}{20}$ th of their first weight.

N ^o 1 weighed	40	Grains, having lost	2	Grains
2	42		4	
3	54		3	
4	53		3	
5	43		3	
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232		15		
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Experiment VII.

For the sake of the greater exactness, another float (marked C) was made of two cubes of cork, amounting to 164 grains; the larger 118, and the smaller 46 grains; this was put into the same vessel of river water, after it had been 96 hours in a warm chamber, and supported a medallion of lead weighing 766 grains; it was left in the water for 36 hours longer, and weighed again, when it was found to support 754 grains, having lost 12 grains of its buoyant force in that space of immersion. From this second experiment does it not appear, that this loss of

of buoyancy was principally owing to the warmth the water had got by standing in a warm room, as was hinted at before, which was further proved by the thermometer?

Two other floats, of 44 grains of cork each, having been 72 hours in river water, weighed each 53 grains, having gained nine grains by the immersion. Being laid to dry for 24 hours after, weighed 46 grains, having relinquished seven grains each.

The float C, being wiped and put into a dry place for 24 hours, was found to weigh 183 grains, having gained 19 grains of weight. The float, in this state, was then immersed in salt water, and was found to support 864 grains, being 110 grains more than it supported in fresh water, after it had been saturated therewith; C, being left in salt water 48 hours, was, upon weighing, found to have lost six grains of its buoyant power. This float C, having been 72 hours immersed in the sea water, was found, after being well wiped, to weigh 203 grains, having increased in weight 20 grains by immersion. After being nine hours out of the salt water it was found to weigh 188 grains, having lost in that time 15 grains.

Experiment VIII.

A medal of lead, weighing one drachm when out of the water, was found, on being weighed in river water, to be 54 grains and a half; being less by five grains and a half than out of the water. The same medal being weighed in the salt water was found to weigh 53 grains and a half. The difference between its hydrostatical weights being precisely one grain, or $\frac{1}{54}$ th more in river water than in sea water.

Expe-

Experiment IX.

A phial of river water weighed exactly 82 grains; the same vessel of sea water weighed exactly 84; the difference was two grains, or as 41 to 42.

Under all these experiments, these cubes of cork did not seem to have gained any measurable extension; yet it is certain the volume of cork, like most other substances, will alter by the imbibition of humidity.

The assertion which has commonly been advanced, that the bodies of men in general are specifically lighter than their respective volumes of water, is not quite perfectly founded in truth; accurate experiments, minutely observed, will satisfactorily evince the contrary to be true. Weighing hydrostatically the human body cannot be so precisely performed, as to permit us to draw any certain inference therefrom, as evidently appears from the imperfect attempts which the ingenious Mr. John Robinson made for that purpose (see Philosophical Transact. Vol. L. Part II. Page 30); on perusing of which, and the author's ingenuous confession of the inaccuracy of his experiments, it occurred, that a more concise and easy method of obtaining a certainty in this particular, might perhaps attend the following attempt to discover the specific gravity of the human body in water.

Experiment X.

After having made the foregoing experiments, with a view of ascertaining the specific buoyancy of cork, and also the alteration it might undergo from being immersed in river or sea water, we proceeded to the more important examen, to discover the precise quantity of cork necessary to sustain a man in the water.

water. For this end, 22 pieces of the best cork, such as is directed to be used for the jackets, * were provided; these were of different weights, from one ounce down to one scruple; so that by means of a string to which they were occasionally fastened, one might easily learn what weight they would suspend in the water, and what weight they would not suspend. This being done, the next business was to find a proper person to make the experiment upon; for the accuracy of which it was judged proper to select a man of the smaller size (as our seamen are seldom large) that was not very fat, because fat people are more buoyant than lean or bony persons; one that could swim, that he might go through the experiment with propriety, and without fear; one, therefore, was fixed upon, who was plump and muscular, not very bony, but moderately so;

His height was five feet two inches;

His waist measured two feet ten inches;

His weight was one hundred and four pounds.

Thus fitted out, he stripped naked, and ten ounces of cork being tied about his neck and breast, he committed himself to the river Thames, near Chelsea, in a place where the water was about a foot below his depth; but he could not keep his head above the surface without employing his art, though he found not much art required to do it: another ounce of cork was therefore added, and he perceived himself raised thereby, so as now to be the more able to keep himself above the water, but yet he went slowly to the bottom, unless he took care by swimming to prevent it. For this reason another ounce of cork was

* The cork jackets proposed for saving the lives of seamen and others in shipwreck are here meant.

applied,

applied, but still he sunk, though more slowly than before; and it was plain to be observed, that the point between that manner of sinking and swimming was balanced with such extreme nicety, that the smallest addition of cork would determine in favour of buoyancy: accordingly half an ounce was added, and this weight supported him in a vibrating state; but by the super-addition of one drachm and two scruples more of cork, he found himself very able to keep above water, in a living position, without any help from his art of swimming, and that it required some small pains to immerse himself. It therefore results from this experiment, that twelve ounces, five drachms, and two scruples, or 6100 grains of cork, supported this man in river water; 6100 grains of cork are equal to $163 \frac{3}{7}$ cubic inches; which appears, by a calculate drawn from the second of the foregoing experiments, to be able to support 63 ounces, five drachms, and eight grains of lead, which must be, therefore, the exact weight of this man in river water. By comparing this calculation with the above experiment IV. made in the sea water, we shall find that this man weighed 60 ounces, three drachms, and 21 grains; or four pounds, 12 ounces, three drachms, and 21 grains, requiring 12 ounces and 21 grains of cork to support him, in sea water. It must however be observed, as we have already intimated, that the same quantity of cork which supports a fat, or very plump person, in the water, will not suffice to buoy up a lean person, although their weights, out of the water, be equal.